THE AVAILABILITY OF CHEMICAL NUTRIENT DATA FOR THE PRAIRIE PROVINCES, CANADA

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Introduction

Great diversity exists in the Prairie provinces with respect to both water quantity and quality. Everything can be found from the abundant supplies of pristine water with nutrient concentrations often below detection (typical of the glacial melt waters of Alberta and the lakes and rivers of the Canadian Shield areas of the provinces) to the hypereutrophic lakes, reservoirs and sloughs of the agricultural, semi-arid central and southern portions. Consequently, in this overview of chemical nutrient data availability, I will emphasize those areas where eutrophication is a major concern while touching only briefly on the remainder of the region.

The problems and symptoms of eutrophication are well recognized by those attending this workshop. The severity is often not appreciated, and the complexities associated with resolving the problem are often poorly understood by resource managers while scientists frequently lack the data necessary to assess the effectiveness of obvious remedial measures, let alone suggest viable alternatives.

My emphasis in this presentation will primarily be the data available for the large river systems which cross international and/or inter-provincial boundaries wherein there is a multi-agency involvement. I have adopted this

approach as this is where Environment Canada, through the Water Quality Branch, plays a role in conjunction with each of the provinces, the Prairie Provinces Water Board (PPWB) as well as various states, and U.S. agencies. In this way, I hope to minimize duplication of presentations made by the provincial representatives.

Before you despair, I assure you I won't bore you with long lists of stations sampled by each agency complete with the parameter lists, frequency, etc., as this information can be obtained from the individual agencies. Rather, I have chosen to bore you with a quick overview of monitoring activities to provide a general impression of the spatial distribution of the current monitoring activities. Subsequently, I wish to illustrate the available chemical data in more detail by reviewing several sub-basins of major interjurisdictional and international significance.

Finally, I wish to briefly note and comment on some of the limitations inherent within the data bases considered. These and other problems would have to be evaluated in detail in any specific manipulation of the data.

Acknowledgements:

I would like to take this opportunity to thank

T. Reynoldson, P. Mitchell, D. Trew and H. Hamilton of Alberta Environment; D. Fast and L. Kratt of Saskatchewan Environment and D. Brown and D. Williamson of the Manitoba Department of Environment and Workplace, Health and Safety, all of whom assisted greatly in assembling this information.

Monitoring Activities: Overview

The Federal Government as well as each of the provinces maintain water quality sampling networks. The Federal Government, under the Department of Energy, Mines and Resources and its forerunners, collected data across Canada as early as 1947. These data are published in a series of technical bulletins referred to as "The Industrial Water Resources of Canada". The earliest reports, published in the mid 1950's, however, emphasized major ion chemistry and excluded nutrients. The sampling program expanded in the west during the 1960's with a laboratory being established in Calgary in the fall of 1967. This laboratory, now operated by Environment Canada, remained in operation to the present in support of a program that expanded annually until very recently. Environment Canada's monitoring locations for the current year (1983/84) are illustrated in Figures 1, 2 and 3.

Under the Prairie Provinces Water Board (PPWB), the WQB

maintains a monitoring program at 11 interjurisdictional river sites. Through an ad hoc agreement with the Province of Alberta, the WQB routinely samples a further 11 sites in that province on the major interjurisdictional river systems. Other than a few of the remote stations, these sites are sampled monthly and analyses includes standard physical and nutrient parameters. The duration of the period of record for all of these stations varies from over ten years to only about three years for some of the Alberta Agreement Stations. The nutrient analyses conducted by WQB include TP, DP, DOC, DN, NO_3 + NO_2, DN, PN, TN-Calculated, PP-Calculated, POC, and NH_3.

The Province of Alberta undertakes extensive nutrient monitoring within its borders; however, since the provincial approach is more toward basin studies, its sampling program will be reviewed below in the discussion of the South Saskatchewan basin.

The program now operated by the Pollution Control Branch of Saskatchewan Environment commenced in 1968 under authority of the Water Resources Conservation Act. Between 1960 and 1975, samples were collected on a "need-priority" basis. The provincial Water Quality Monitoring Network was introduced in 1975. Initially, many types of stations were maintained; but recently, there has been a shift toward

monitoring only a select number of primary stations combined with more specialized problem oriented studies. The primary monitoring stations are shown in Figure 2. These 13 stations are sampled monthly and routinely analysed for TKN, NO_3, NH_3, TP, Ortho P, Total C and TOC.

The Province of Manitoba maintains an extensive monitoring network of some 90 stations generally sampled monthly. Monitoring at these sites commonly commenced in the early or mid 1970's while some station records date to 1965. Nutrient data for these stations included TKN, NH_3, NO_3 + NO_2, TP, TOC and TIC. Figure 3 only shows the federally operated stations in the Province of Manitoba.

In addition, numerous trophic assessments have been undertaken within Manitoba lakes by the Province and extensive studies of Lake Winnipeg have been conducted by the province as well as by DFO personnel at FWI. Water quality assessments were also undertaken in the Souris River basin under the auspices of the Souris River Study Board during the 1970's.

The water quality data generated through the WQB monitoring program is published periodically by the Branch. The most recent data publications are for the years 1977 to 1979. The PPWB publishes all data for the 11 network stations

annually. All of these data are stored on NAQUADAT, the National Water Quality Data Base. Each of the provinces maintains their own water quality data base for their own data. The provinces frequently amalgamate federal and provincial network data within their data bases.

Basin Studies

As noted above, the provincial agencies, and to a lesser extent WQB have been directing more attention to basin studies. It is through a review of the nutrient data available in several of these basin studies that I propose to illustrate more fully the nature of the nutrient data available for the Prairie Provinces. Two basins will be considered; specifically, the South Saskatchewan, and the Qu'Appelle.

(i) The South Saskatchewan Basin

Eutrophication has recently become an issue in this basin, first with the effects of Calgary sewage on the Bow River and more recently with the concern to maintain the quality of Lake Diefenbaker. This latter issue is directly associated with the taste and odour problems of Regina and Moose Jaw drinking water and the possibility of using Lake Diefenbaker as a source of potable water. Consequently, I

will focus discussion here on the portion of the South Saskatchewan system upstream of the Gardiner Dam.

The South Saskatchewan above the Gardiner Dam has a drainage basin area of 136,000 km^2. The watershed, although primarily within Alberta, includes a considerable portion of Saskatchewan as well as a small section in northwestern Montana (Figure 4).

In addition to the monthly monitoring undertaken by WQB and SDOE, Alberta Environment has undertaken intensive monitoring of the South Saskatchewan River Basin. The study, titled the South Saskatchewan River Basin Eutrophication Control Study (SSRBECS) was initiated in 1979 for the purpose of:

(i) quantifying significant nutrient sources to the Bow, Oldman and South Saskatchewan Rivers;

(ii) defining the relationship between nutrients and aquatic plant growth in the basin; and,

(iii) predicting the impact of point source nutrient control on plant growth.

The activities noted below were undertaken as part of this study:

(i) a basin-wide total phosphorus source inventory;

(ii) a feasibility study of advanced phosphorus removal at Calgary;

(iii) monitoring at selected sites for water chemistry data;

(iv) an investigation of river sediment chemistry;

(v) the collection of biological data including estimation of macrophyte and benthic algal growth rates, standing crops and species structure;

(vi) algal assays to provide a direct measure of phosphorus bioavailability.

The field work for this study continued into 1983. A water quality management model is being developed to forecast the impact of reduced phosphorus loadings and other relevant environmental parameters on the growth of aquatic plants and algae in the South Saskatchewan River system. The sampling sites for the SSRBECS are shown in Figure 4.

The data generated by the South Saskatchewan River Basin Eutrophication Control Study is still under review by Alberta Environment. However, some preliminary results are available which show the scope of the studies findings. Figures 5, 6 and 7 show annual cycles above and below the City of Calgary for selected chemical and biological parameters. It is worth noting that both DP and TP at site 7 near the confluence of the Bow and the South Saskatchewan, are very close to background during the summer period apparently due to nutrient uptake by the macrophytes and other plants as well as other system

losses. The macrophyte densities during August and September downstream of the Bonnybrooke STP at Calgary are illustrated in Figure 8.

The mean TP and DP concentration for May to August, 1979, for both the Bow, Oldman and South Saskatchewan Rivers is shown in Figure 9. The rapid decrease in TP and DP concentrations downstream of Calgary is quite evident. However, the contrast between DP and TP concentrations in the Oldman River downstream of Lethbridge is noteworthy. The more turbid Oldman River has a much higher background TP concentration indicative of its fine grained agricultural drainage basin. These suspended solids apparently adsorb much of the DP with the result that DP remains relatively low. The bioassay data, expressed as algal growth potential (Figure 10) indicates the relative bioavailability of P in the two systems.

Lake Diefenbaker is the largest high quality reservoir in central Saskatchewan and consequently is of inestimable value as a domestic water supply, for recreation and for irrigation as well as many other uses. The protection of this lake is key to maintaining the value of this resource. The material presented above clearly indicated the impact of point source

inputs on the river systems in Alberta; but, unfortunately, no complementary work has been undertaken downstream of the Alberta/Saskatchewan border. As well, a similar study has not been undertaken for the Red Deer River Basin. The effect of upstream agricultural activities and urban inputs on Lake Diefenbaker cannot be evaluated without a coordinated assessment of the whole basin. The results of this type of assessment will provide the information base necessary to effectively manage the South Saskatchewan basin.

(ii) The Qu'Appelle River Basin

The Qu'Appelle River Basin above the Saskatchewan/Manitoba border has an area of 50,800 km^2. The basin (Figure 11) contains predominantly agricultural land. The two largest urban centres are Regina and Moose Jaw. Included in the Qu'Appelle Basin are eight lakes of which the largest is Last Mountain Lake. Buffalo Pound serves as the drinking water supply for Moose Jaw and Regina while the other lakes in the system are important recreationally.

The lakes are highly productive. Allan et al (1980) suggested that these lakes have been subjected to relatively high nutrient loads since before European

settlement of the basin. Early explorers reported scums on the lake surface probably a result of algal blooms, during the summers. Nonetheless, sod breaking, continuing agricultural activities and urban development have further stressed these lakes.

As part of the Qu'Appelle Implementation Agreement signed by Canada and Saskatchewan in 1972, remedial works and monitoring activities were planned for the basin. Moose Jaw has implemented an effluent irrigation system and has essentially eliminated its discharges to the system. Regina implemented tertiary treatment with phosphorus removal in 1977. Improved sewage facilities are in the works for several smaller centres. However, the question arose as to the effect of these remedial measures. The Qu'Appelle Valley Management Board accepted recommendations to undertake additional monitoring for loadings estimations and in lake productivity surveys in conjunction with other work. The in-lake surveys have never been undertaken; whereas, the WQB undertook intensive input and output monitoring above and below Pasqua and Katepwa Lakes, respectively. Composite samples were collected every 2 1/2 to 3 days above Pasqua Lake using an autosampler. Grab samples were taken at the same frequency below Katepwa Lake. This sampling program began in April 1980 and continued,

until being prematurely terminated, in June 1983. Routine analyses included total and dissolved phosphorus and total and dissolved nitrogen. Additional samples were collected less frequently for Ortho-P, total inorganic-P, and dissolved inorganic-P analyses. Although the data are still being assessed, some of the preliminary results are very interesting.

The phosphorus and nitrogen data for the period April, 1980 to January, 1983 are graphed in Figures 12 and 13. Of interest in the phosphorus graphs is the difference in the ratio of DP to TP between the two sites and the general impact of hydrology. There is an order of magnitude change between input and output TN and DN concentrations. A strong seasonal effect, probably tied to base flow quality under ice cover, is evident at the Pasqua site. Ice cover in the lakes does not have a clear impact on the trends.

The nutrient loading calculations are summarized in Table 1. The effect of hydrology is quite evident in the input load, but surprisingly, it also seems to have affected the output load such that during the "moderate flow" year of 1982, more TP and DP left the system than was brought in in that year. During low flow years (1980 and 1981), the lakes retain 70 to 80% of the TP,

most of which is in the particulate form. The lakes always seem to "retain" or utilize large portions of the incoming nitrogen.

Although these results are very interesting, they are inconclusive for a number of reasons. Hydrologic regime is an important factor but the period of record for the data is too limited to assess its significance. In lake biological, chemical and physical process data are all but non-existent yet are critical to understanding these loading data and assessing any impacts on the lakes. Although WQB is anxious to reinstitute this monitoring program, it is of limited value without the corroborative studies.

Discussion

There are other basins I could discuss in this manner, including the Red and the Souris. However, I have emphasized basins in Saskatchewan and Alberta as you have learnt about Manitoba through the field program and I wish to reserve some time for general comments regarding the chemical nutrient data for the Prairie Provinces.

Chemical nutrient monitoring should provide a key component of the data base necessary to advise water resource managers

regarding impacts, remedial options and effects of eutrophication. If this objective is to be achieved, the nutrient data should provide:

(i) accurate estimates of nutrient loadings and fluxes for the major sources;

(ii) an indication of the effect of chemical, physical and biological processes on nutrient cycling and biological availability;

(iii) adequate and consistent coverage for the system;

(iv) a data set capable of being used in simulation models for evaluating remedial measure options;

(v) data from the monitoring network over a sufficient period of time to meet the preceding objectives.

There is no question that there are volumes of chemical nutrient data available covering fairly long periods of time and with reasonably good spatial coverage. The question of the ability of these data to meet the above objective, however, must be considered in the context of large, interjurisdictional dynamic Prairie river systems. I wish only to throw out as discussion items, the major limitations as well as some general comments (Table 2) as I see them, relating to the collection and use of nutrient monitoring data.

As long as routine monitoring programs as they presently exist provide a major component of the chemical nutrient data base for the Prairie Provinces, many of the limitations

and criticisms will continue to stand. However, adoption of a basin approach to studies and even monitoring activities has the potential to minimize many of the apparent limitations. For example, a basin approach overcomes the severe limitation imposed by monitoring at boundaries or conducting studies within a single jurisdiction; further, it permits and requires a great deal more coordination of effort and tends to formalize commitments among jurisdictions. In general, more emphasis on a basin approach is required to meet the information needs of resource managers if nutrient related problems in the Prairie system are to be understood and managed effectively.

REFERENCE

Allan, R. J., J. D. H. Williams, S. R. Joshi and W. F. Warwick. Historical Changes and Relationship to Internal Loading of Sediment Phosphorus Forms in Hypertrophic Prairie Lakes. J. Environ. Qual. Vol. 9, No. 2, 1980.

Figure 1: **WATER QUALITY SAMPLING STATIONS - ALBERTA**

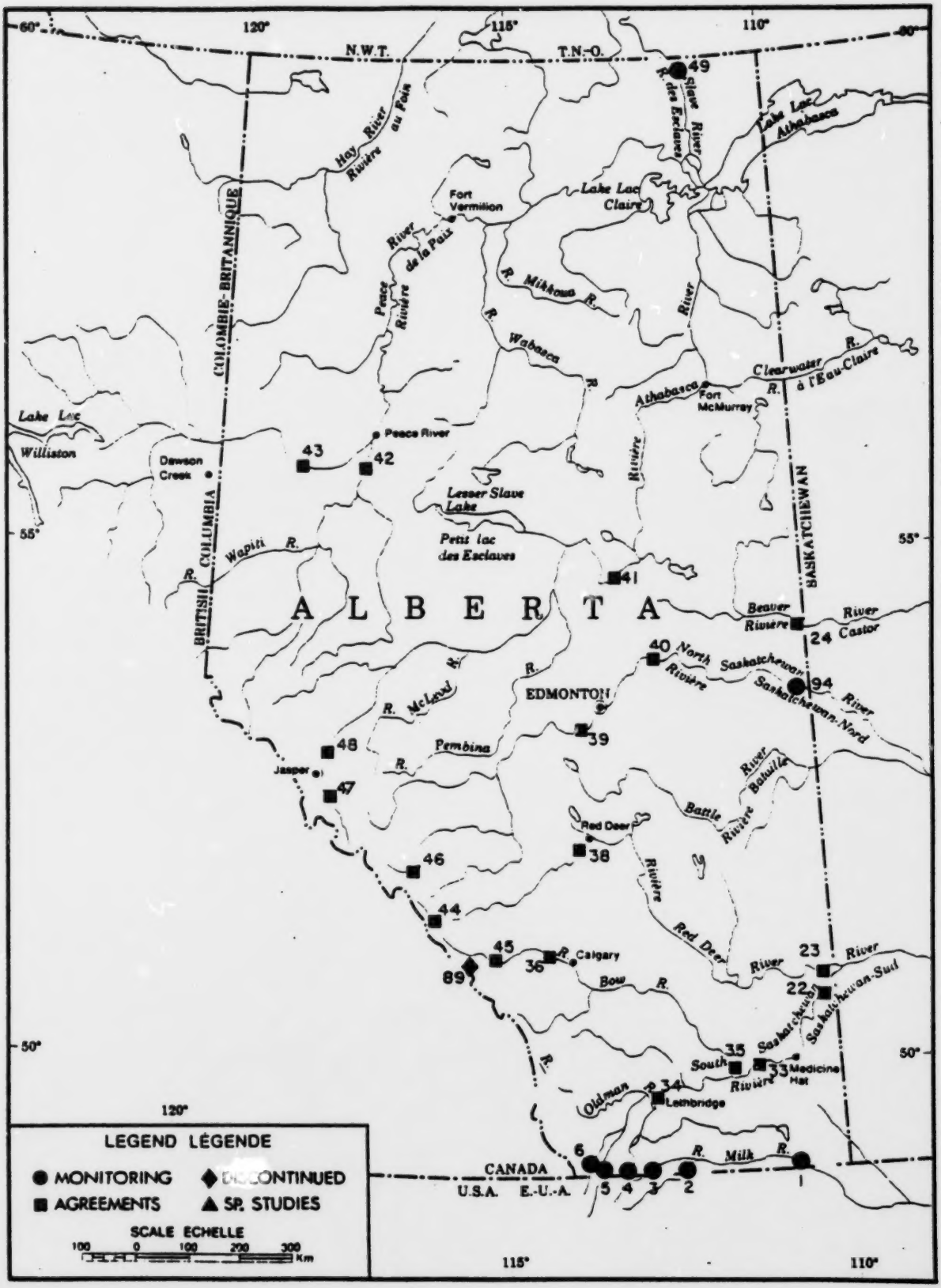

Figure 2: **WATER QUALITY SAMPLING STATIONS – SASKATCHEWAN**

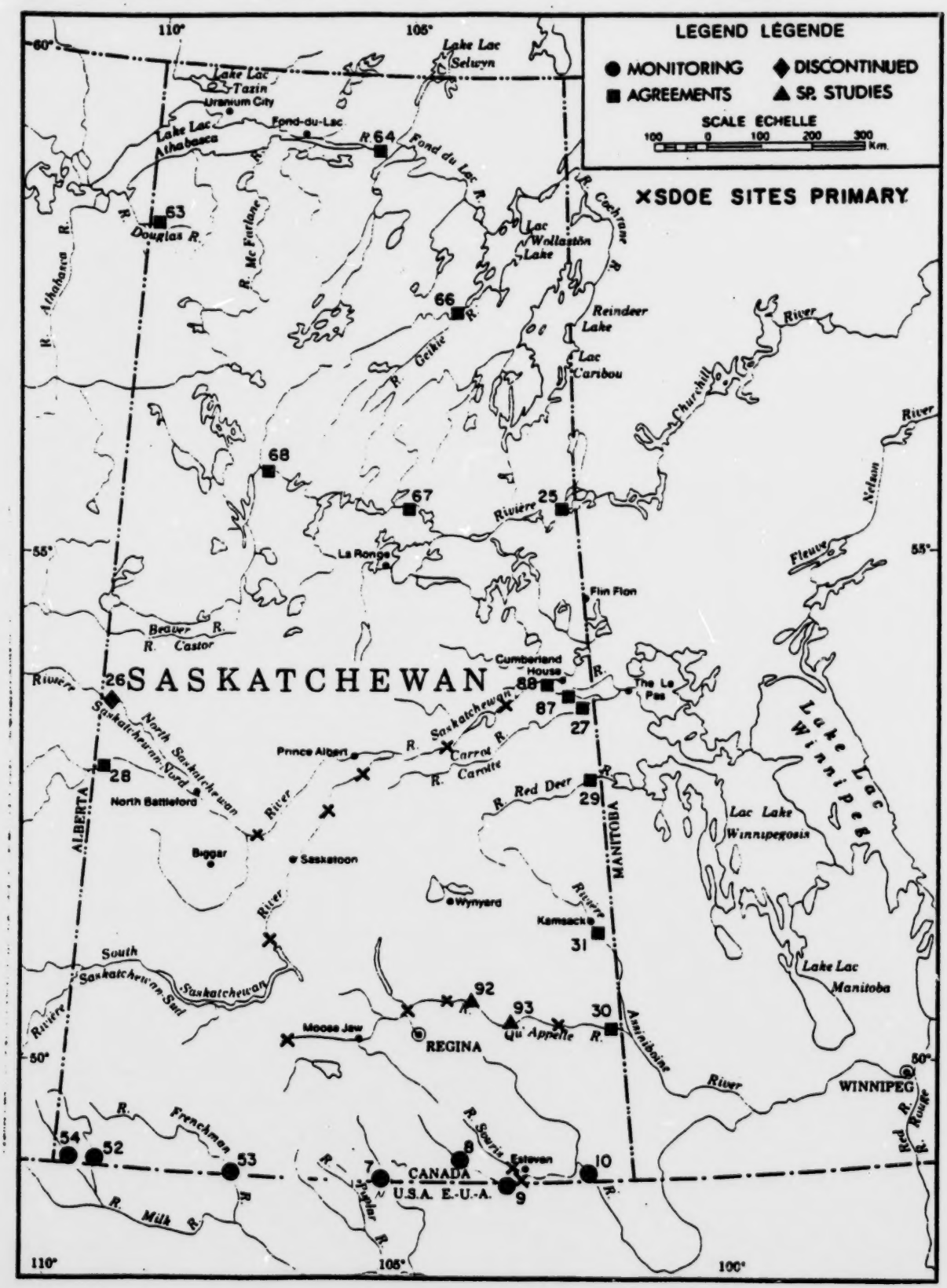

Figure 3: WATER QUALITY SAMPLING STATIONS - MANITOBA

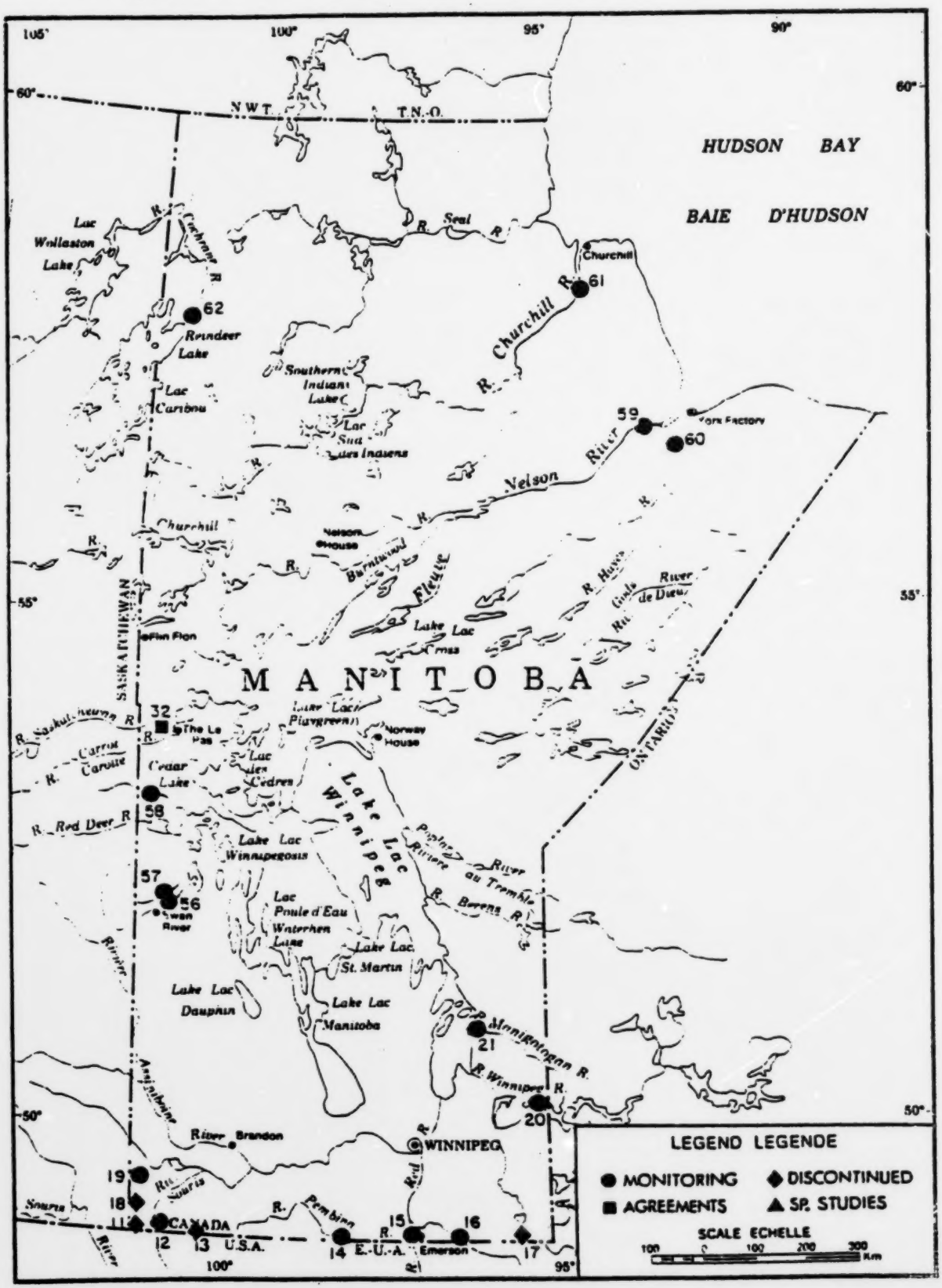

Figure 4: The South Saskatchewan River Basin Water Quality Sampling Stations.

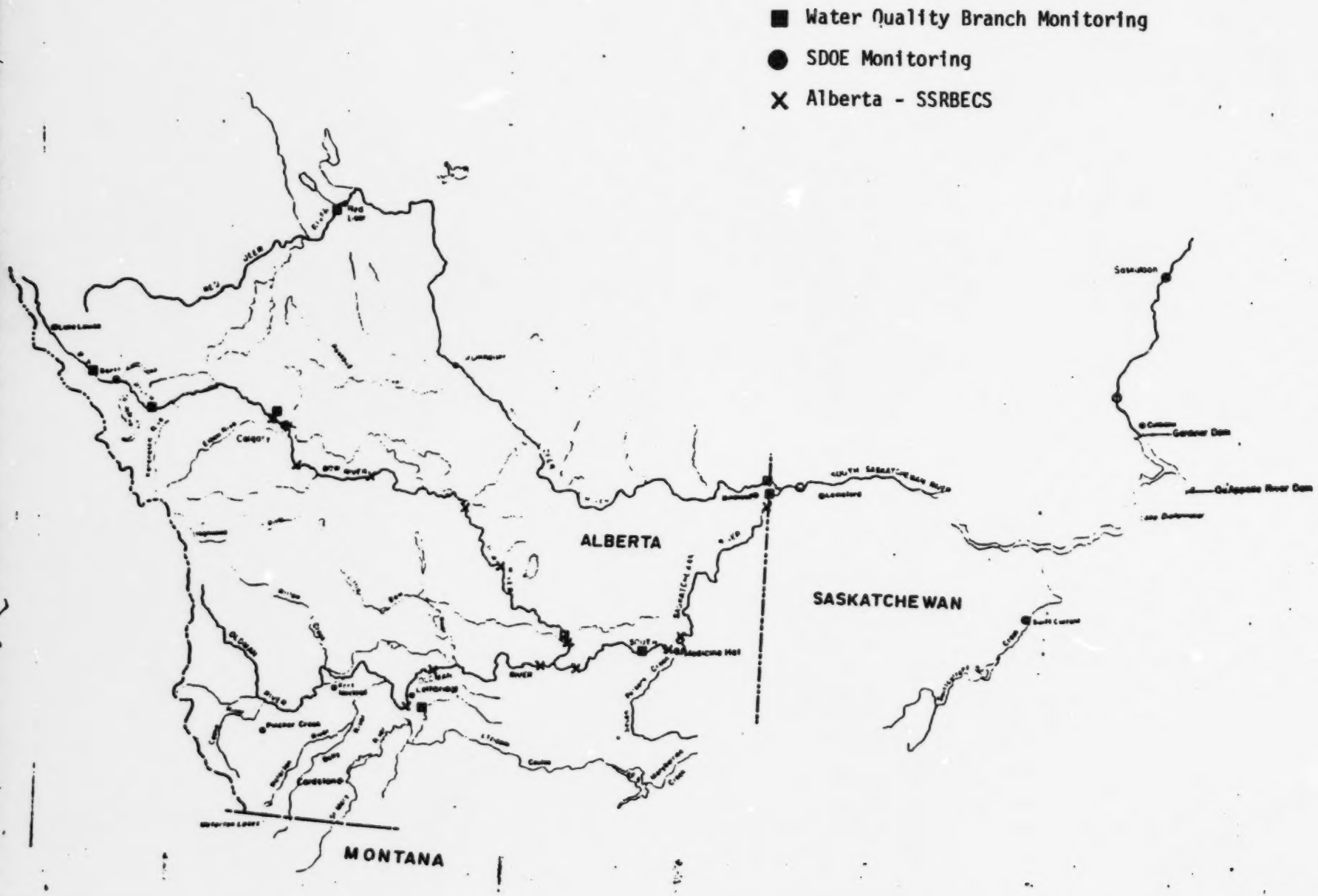

FIG: 5 BOW RIVER SITE I
SELECTED CHEMICAL AND
BIOLOGICAL PARAMETERS

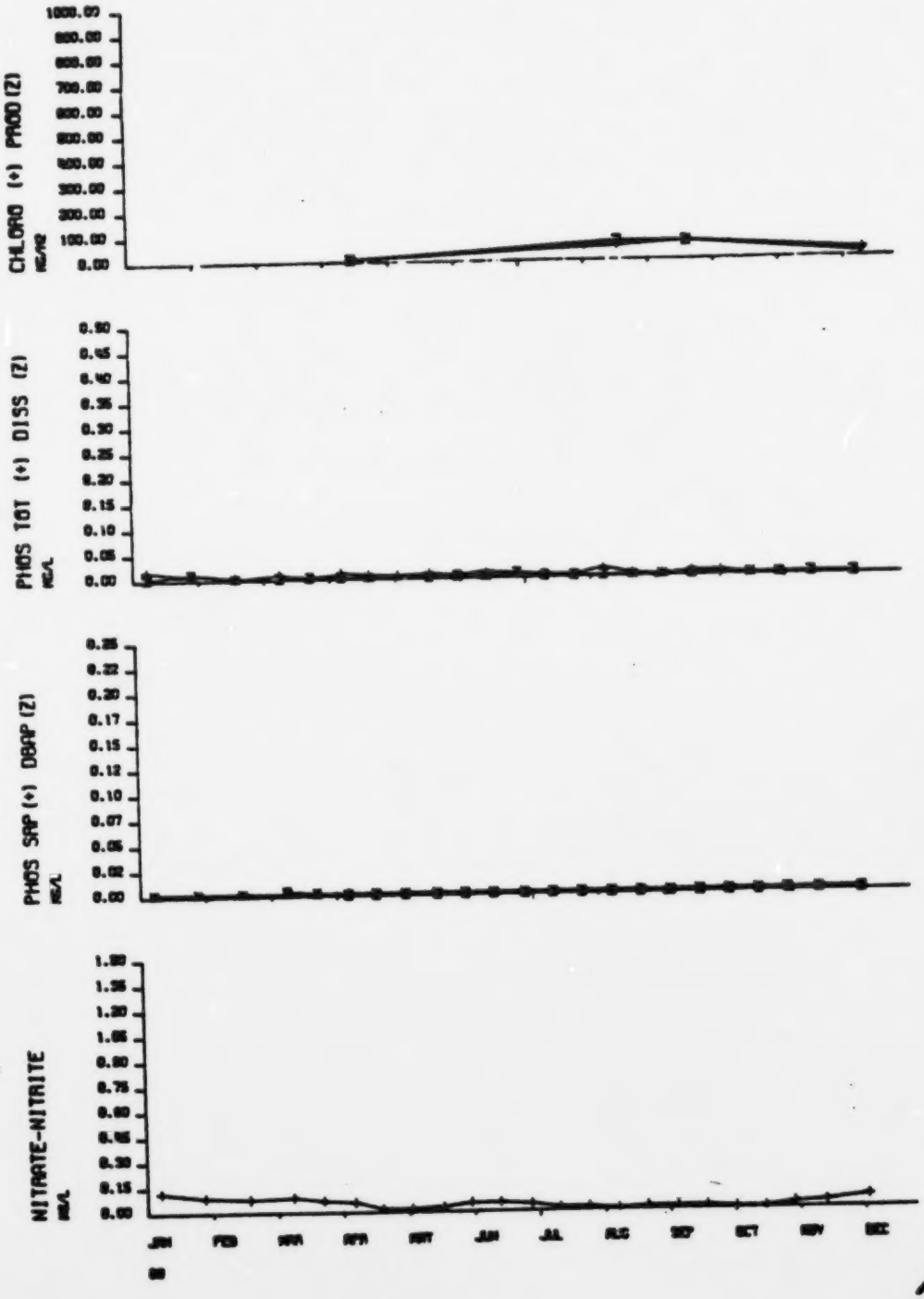

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FIG. 6 BOW RIVER SITE 5
SELECTED CHEMICAL AND
BIOLOGICAL PARAMETERS

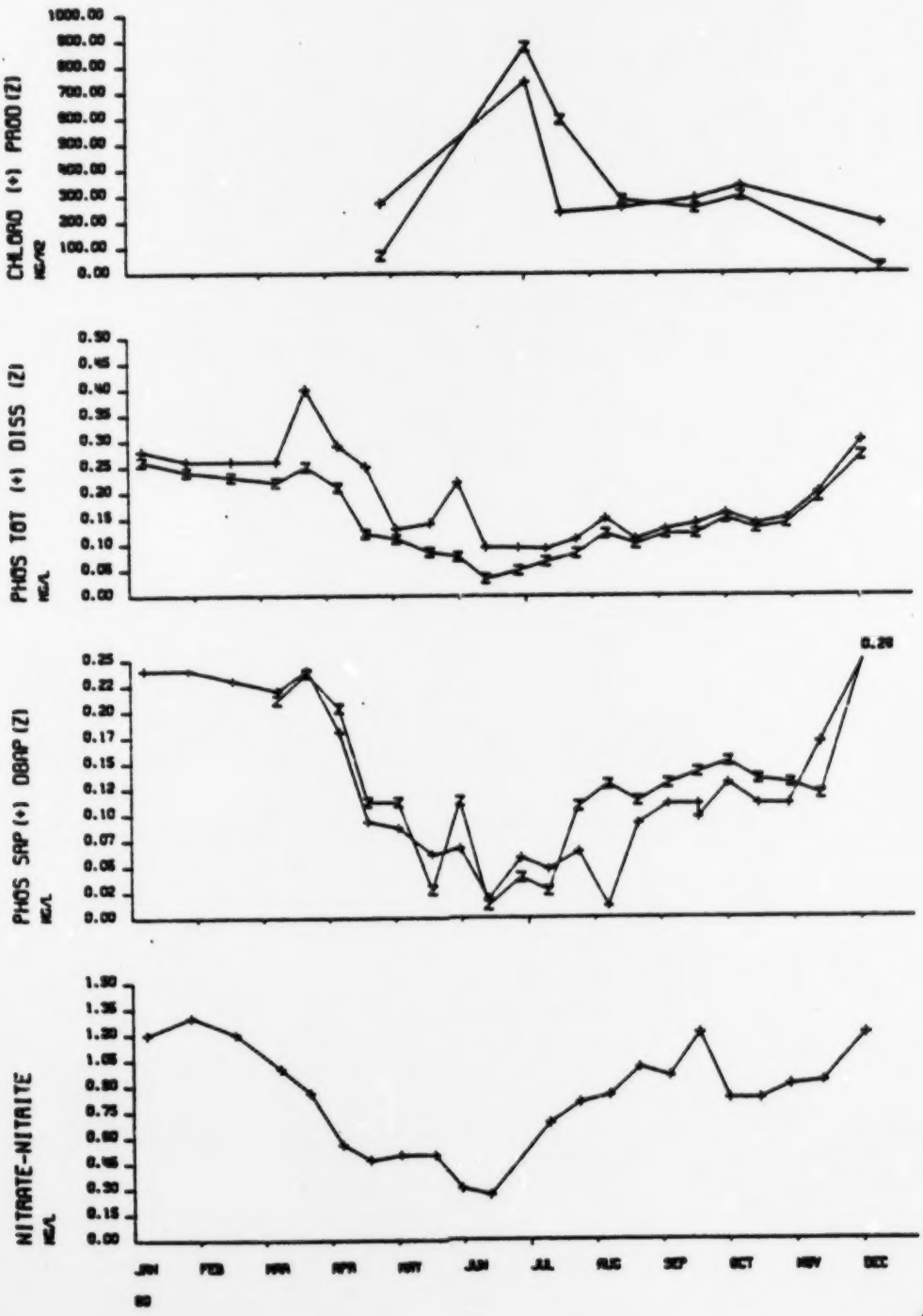

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FIG. 7: BOW RIVER SITE 7
SELECTED CHEMICAL AND
BIOLOGICAL PARAMETERS

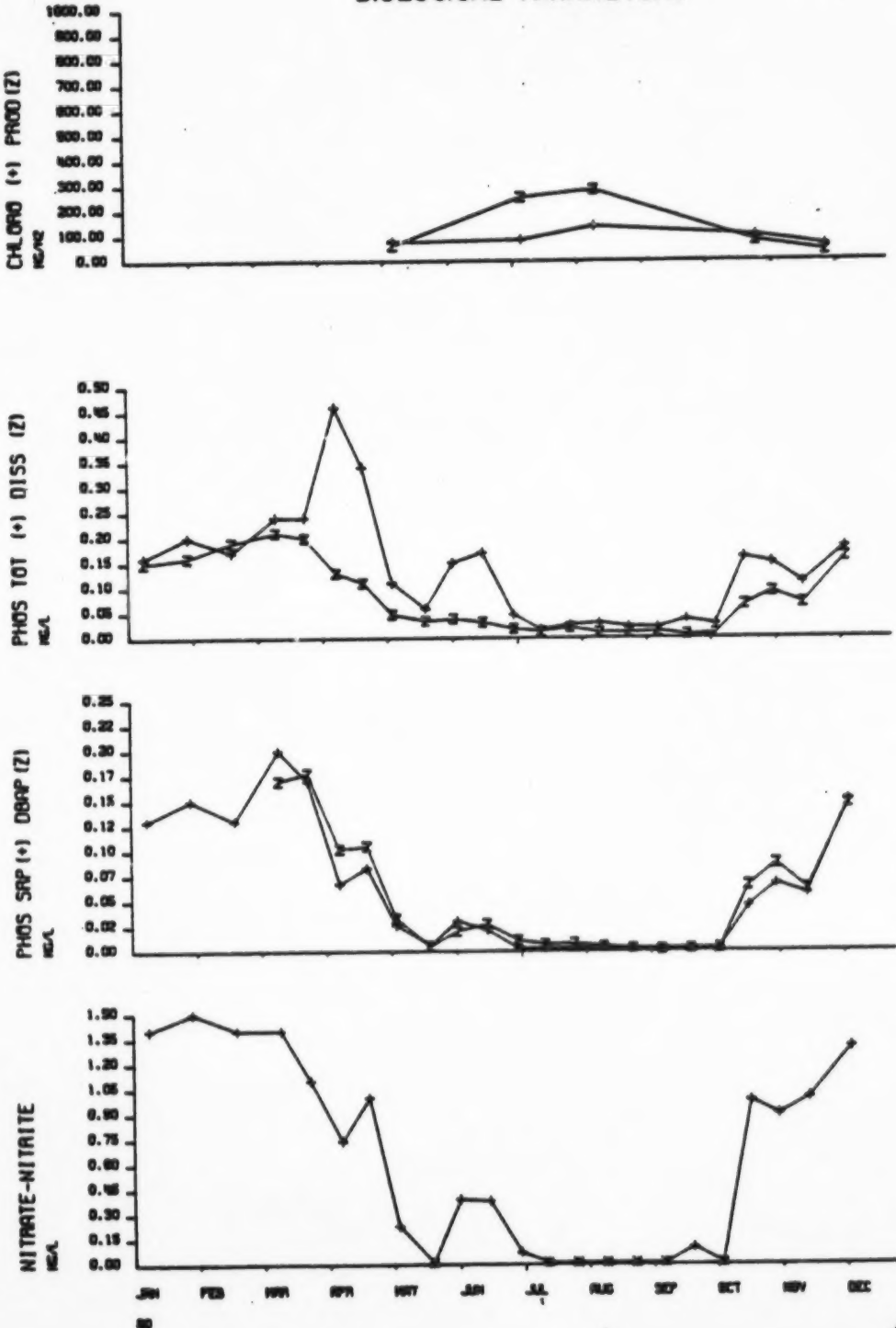

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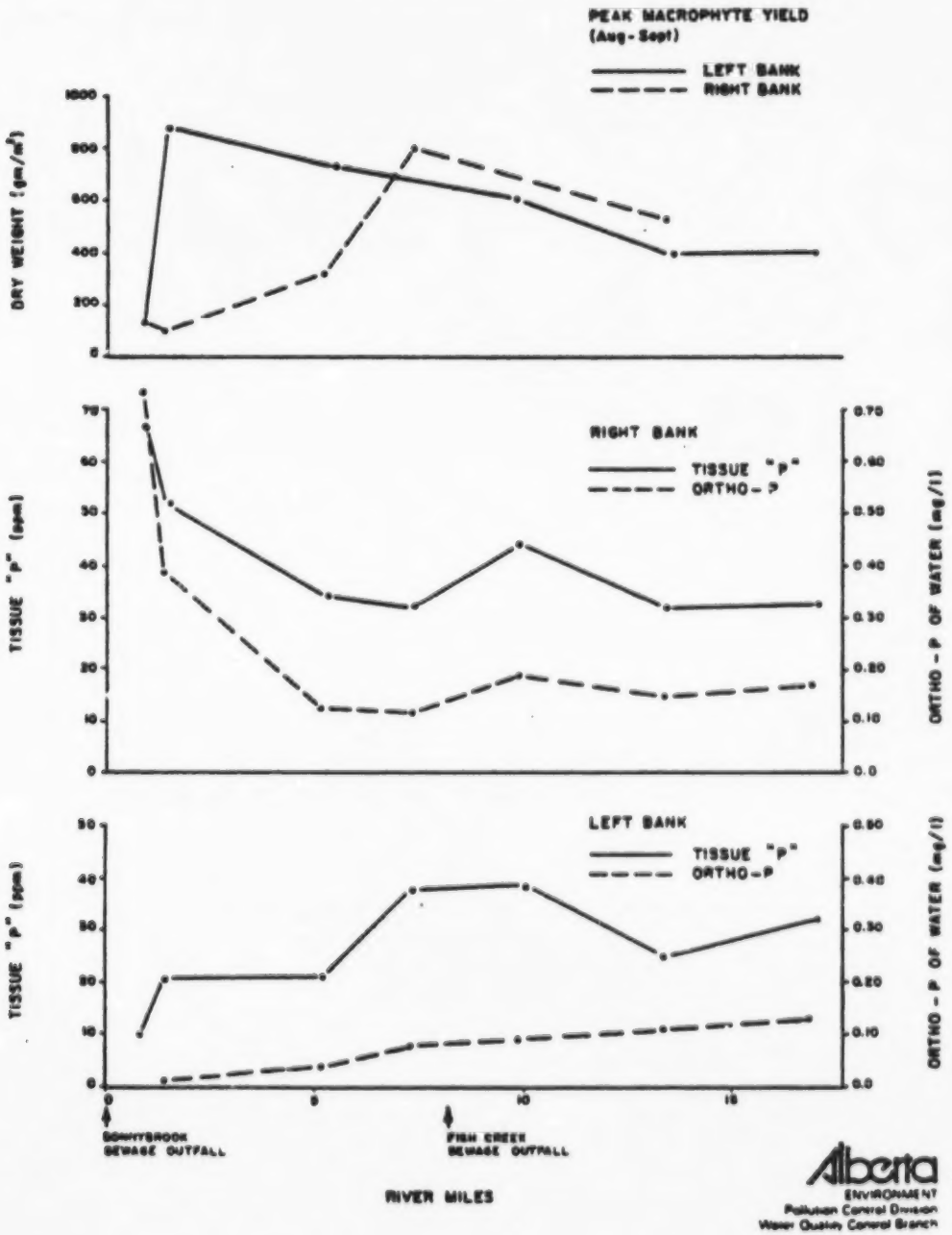
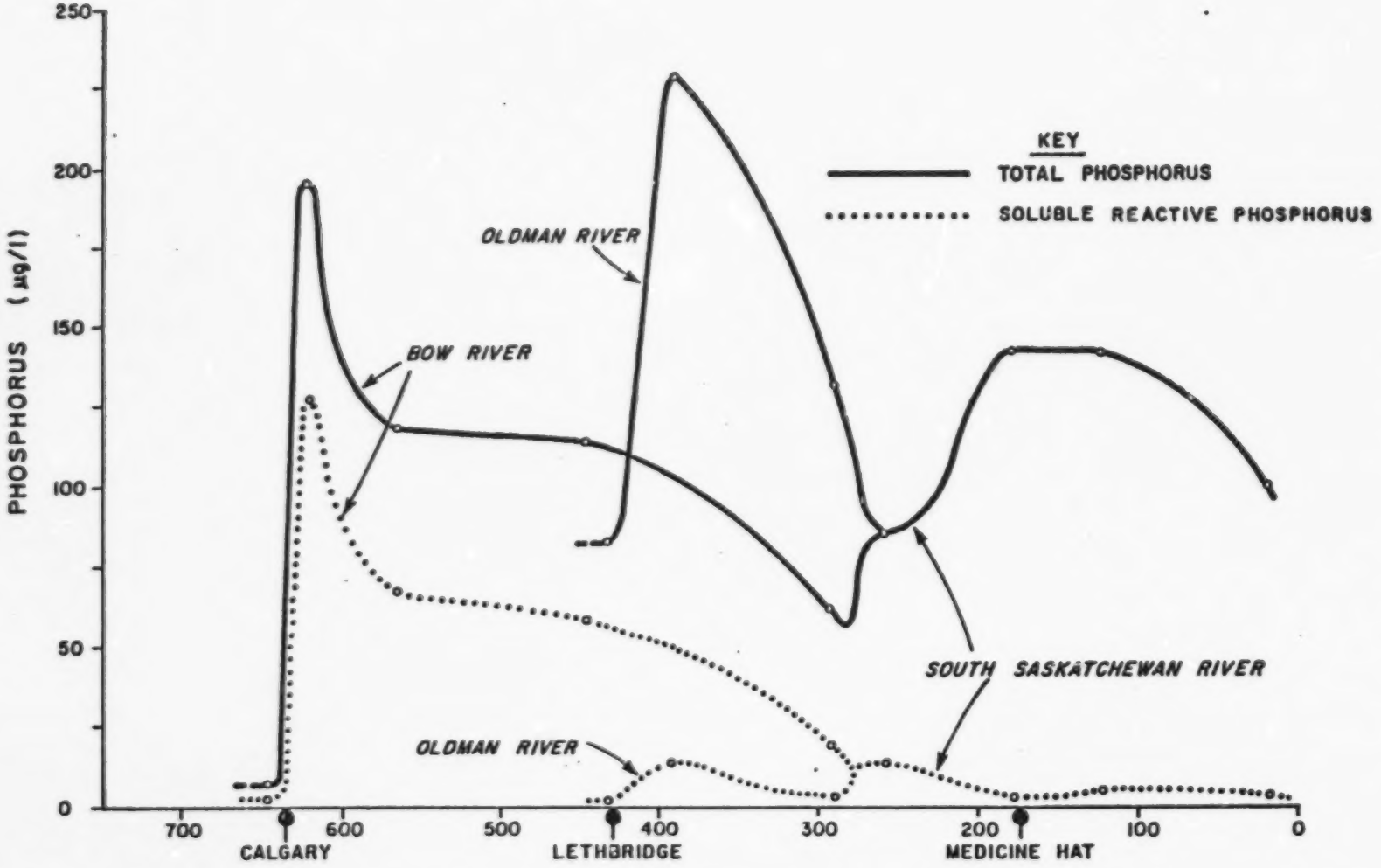
FIG. 8: MACROPHYTE DENSITIES, TISSUE "P" CONCENTRATION AND ORTHO-P BETWEEN BONNYBROOK SEWAGE TREATMENT PLANT AND BOW SITE 2.





MEAN PHOSPHORUS CONCENTRATION

MAY - AUGUST, 1979

FIGURE 9

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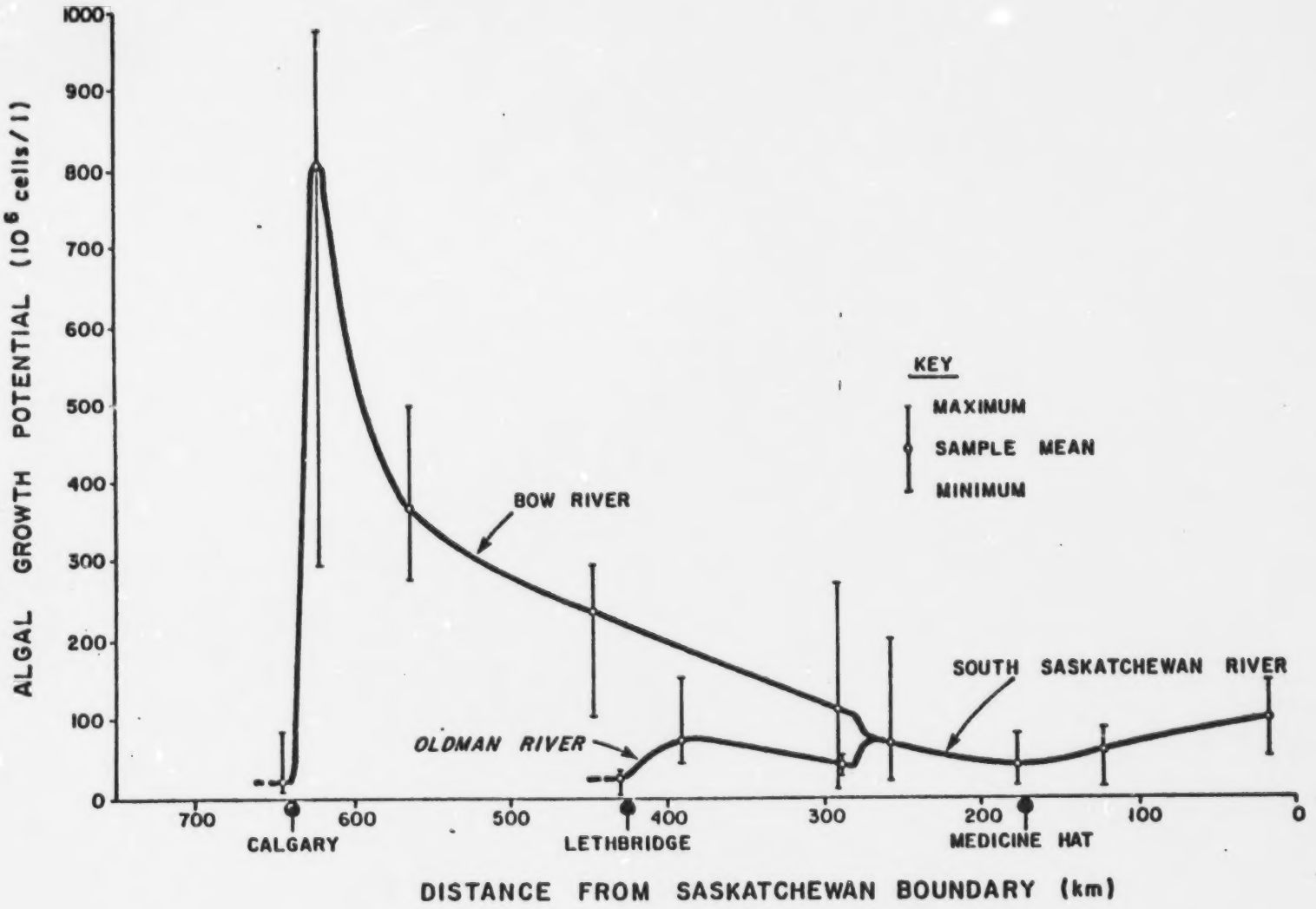

ALGAL GROWTH POTENTIAL (S. capricornutum)

MAY - AUGUST, 1979

FIGURE 10

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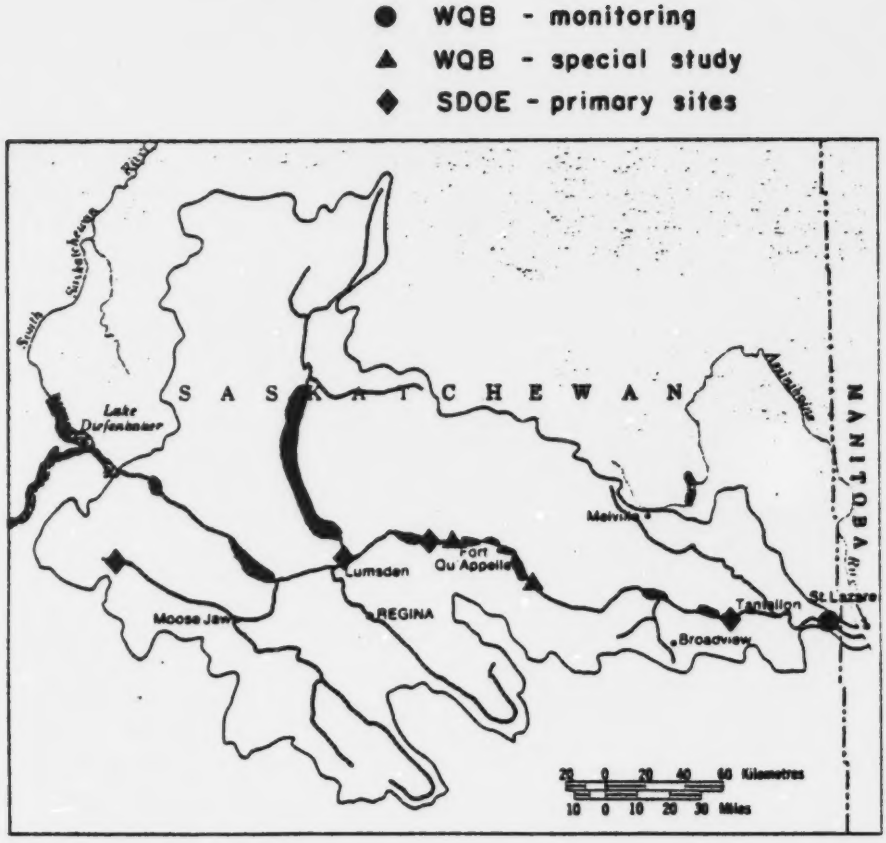
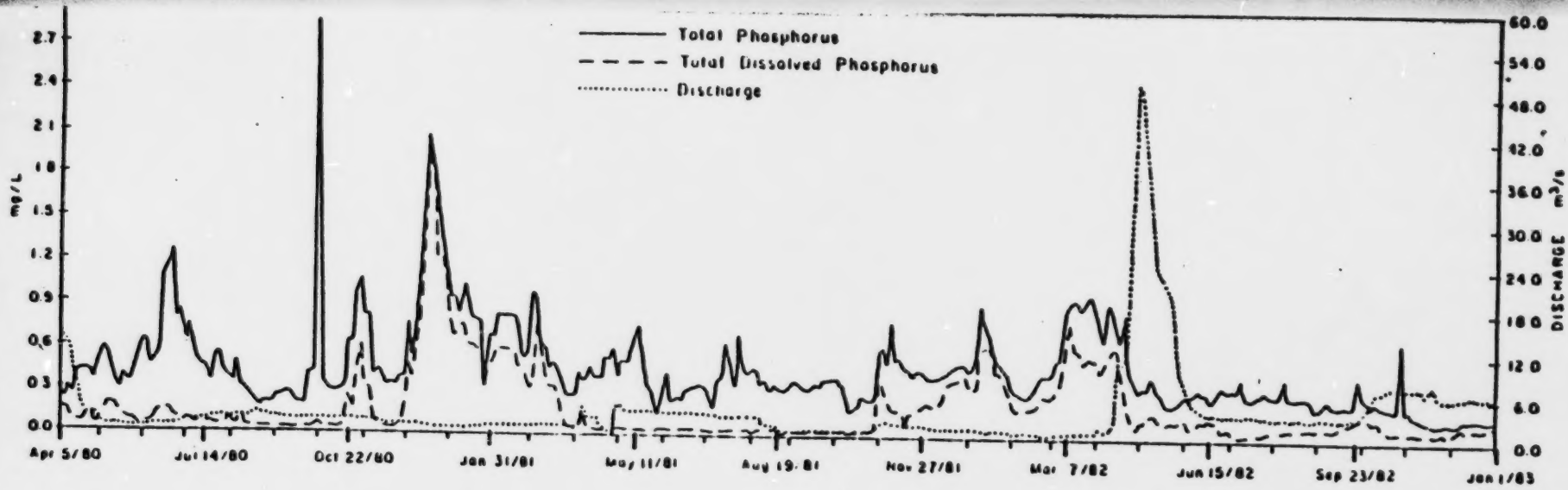
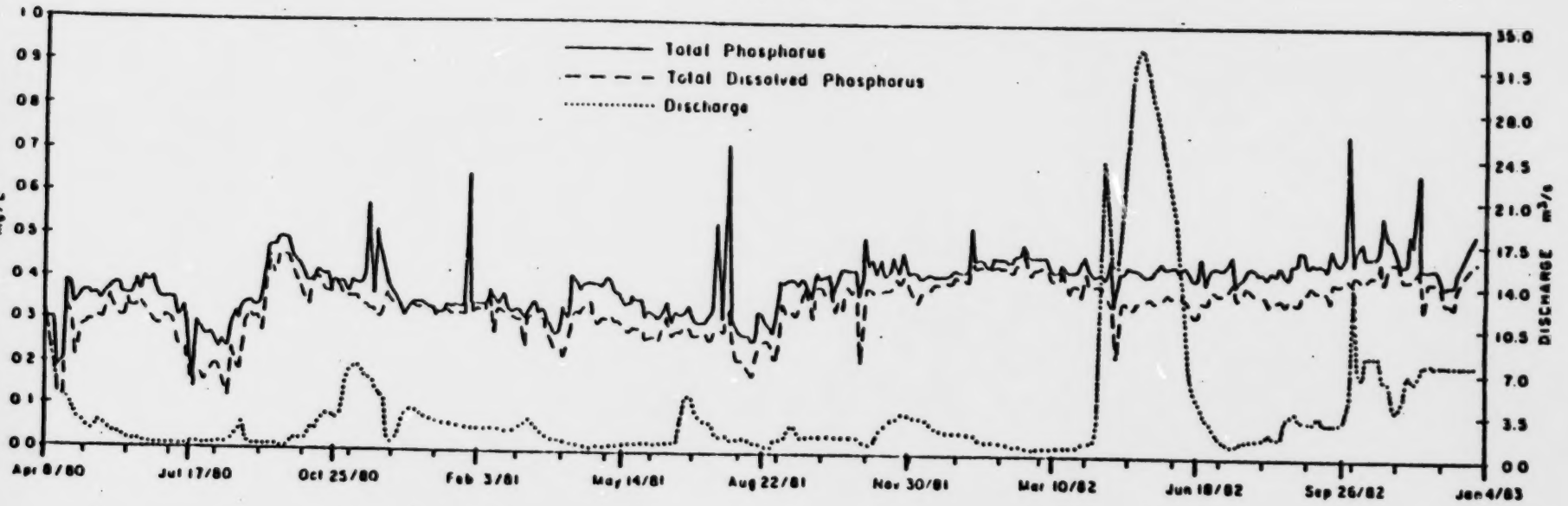
Figure 11: **Qu'Appelle River Basin**



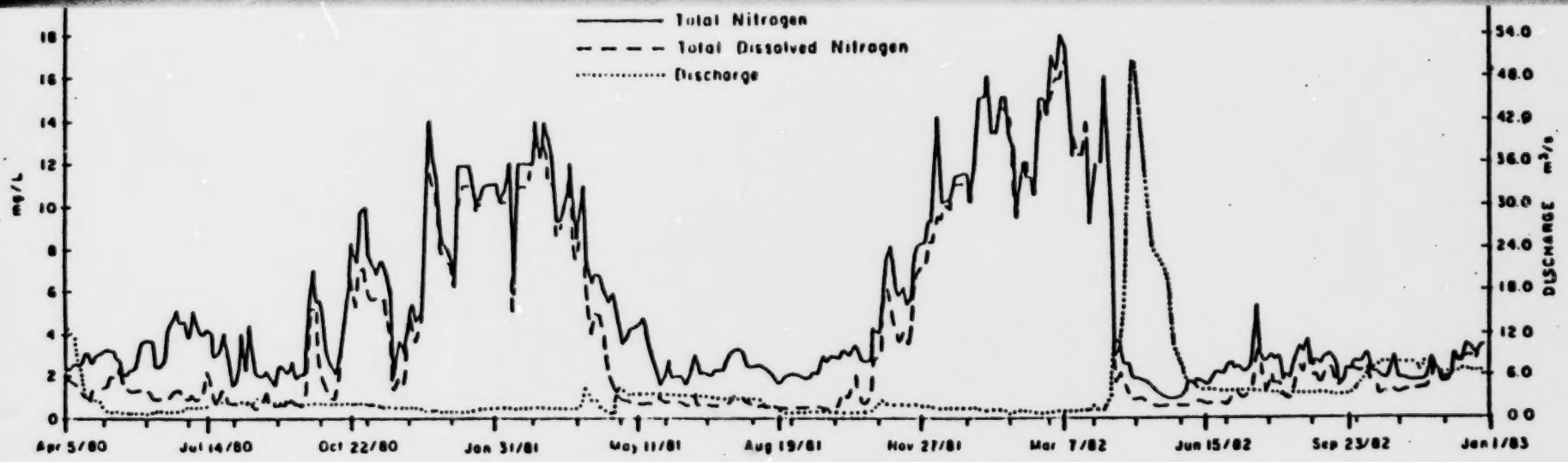


Discharge and Phosphorus Concentration in the Qu'Appelle River above Pasqua Lake, April 1980 to December 1982.

Figure 12

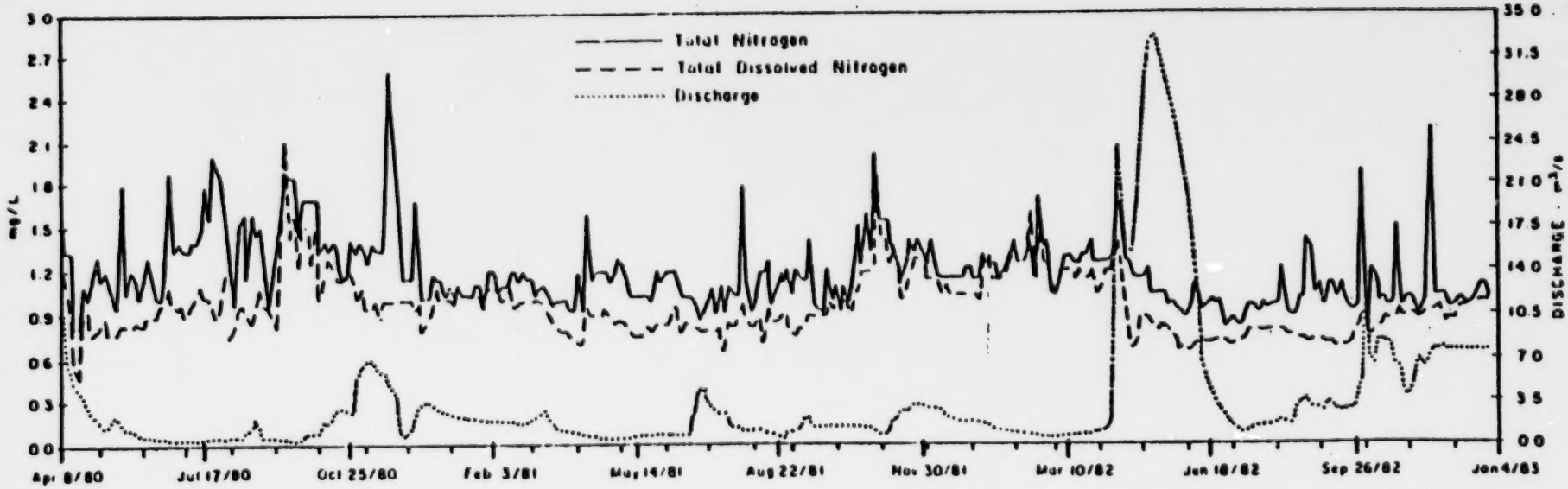


Discharge and Phosphorus Concentration in the Qu'Appelle River below Katepwa Lake, April 1980 to



Discharge and Nitrogen Concentration in the Qu'Appelle River above Pasqua Lake, April 1980 to December 1982.

Figure 13



Discharge and Nitrogen Concentration in the Qu'Appelle River below Katepwa Lake, April 1980 to December 1982.

Table 1. Discharge and Nutrient Loading in the Qu'Appelle River

Year	Qu'Appelle River above Pasqua Lake					Qu'Appelle River below Katepwa Lake				
	Discharge (dam^3)	TP	DP (Tonnes)	TN	DN	Discharge (dam^3)	TP	DP (Tonnes)	TN	DN
1980 Apr. - Dec.	49,200.	19.76	8.04	175.3	111.3	52,300	16.50	13.85	64.72	44.49
1981	54,700	24.45	8.42	291.5	202.2	47,500	17.03	15.20	50.59	44.42
1982	202,000.	59.66	26.49	469.9	342.4	212,000	94.08	78.4	213.0	172.7
1983 Jan. - June	125,500.	NV	NV	NV	NV	140,400.	NV	NV	NV	NV

Note: The 1983 load calculations are incomplete at this time.

Table 2: Observed Limitations of the Chemical Nutrient Data for the Prairie Provinces

(i) lack of coordination among jurisdictions resulting in inconsistent data within systems;

(ii) absence of flow-dependent sampling in most monitoring programs and some studies;

(iii) overemphasis on fluvial stations relative to lake stations in most monitoring programs;

(iv) absence of physical and biological data in support of chemical monitoring programs;

(v) different sampling and analytical methods among jurisdictions;

(vi) changing analytical methods within labs;

(vii) tendency to collect new data before reviewing existing data;

(viii) untimely termination of special studies;

(ix) a tendency to apply techniques for remedial measures and/or monitoring strategies which have not been fully assessed in the Prairie system, often at considerable expense and limited or perhaps unquantifiable benefits;

(x) over-dependency on inadequately evaluated water quality objectives determined at boundary locations for managing basins.

(xi) lack of information on biologically available species of nutrients related to seasonal and hydrologic variability;

(xii) lack of sufficient detail in data bases to identify sources, seasonal fluxes and other processes determining temporal variability;

(xiii) frequent incongruity between the purposes of monitoring programs and special studies;

(xiv) as a result of the individual or combined effects of these limitations resources may be misdirected in an effort to evaluate remedial activities without proper baseline data prior to the intervention with

the result being that benefits are frequently not quantified and monitoring and special studies are perceived negatively;

(xv) a lack of interpretation of monitoring data through integration with other information to fully assess the monitoring data and provide advice to managers in a timely manner regarding impacts or needs for special studies.